Robust Prediction of High Lift Using Surface Vorticity, Phase II

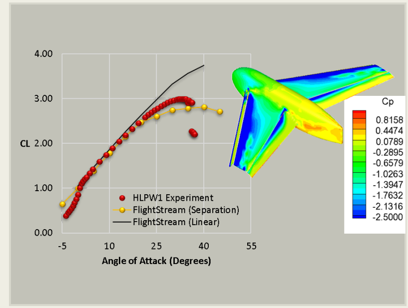
Completed Technology Project (2017 - 2020)

Project Introduction

FlightStream has been developed a fast, accurate, aerodynamic prediction code based on vorticity computations on the surface of an aircraft. The code, though still a surface paneling algorithm, has proven to be significantly more robust and computationally efficient. FlightStream uses CAD or an unstructured surface mesh and is adaptable to subpanels varying in vertex valence from triangles to surface polygons. The focus of the recently completed Phase-I effort preceding this proposal has been to develop the viscous formulation of surface-vorticity to allow the prediction of non-linear aerodynamics and the onset of flow separation through a new approach called the Fluid Strain-based Separation model. This theoretical development and demonstration has laid the foundation for an effective, high-fidelity, physics-based solution for flow separation. In this Phase-II proposal, the focus is to expand the scope of application of these non-linear aerodynamics and flow separation models through robust algorithmic implementation to the FlightStream code base. A part of this focus will also be to validate the conclusions obtained from the strain-based separation model about the nature of fluid flow and to develop fundamental relationships between the proposed Maximum Fluid Strain property and the primary fluid properties with regard to flow separation. Several major performance and fidelity enhancements are also proposed for this effort that are expected to place FlightStream in a very unique position in the aerospace industry. These include the application of the Fast Multipole Method for improving the solver speed and reducing its memory footprint; a higher-order vorticity sheet solver to improve the fidelity of the solutions and improve solver stability in non-linear flow environments and other mutually supporting enhancements. Research in Flight hopes to use this current effort to develop the very first commercially viable viscous, surface-vorticity, flow solver.

Anticipated Benefits

FlightStream is currently used in a variety of different applications by NASA and the industry. These applications can be categorized in the following manner: * Steady-state cruise aerodynamic performance * Propeller-wing interactions * Take-off / landing aerodynamic performance * Engine integration studies * Multi-disciplinary optimizations The impact of the non-linear aerodynamics and flow separation models developed as part of this effort will have a direct impact on the first three application areas listed above. Namely, steady-state lift cruise aerodynamics, propeller-wing interactions and take-off/landing aerodynamics. The implementation of a robust model for predicting maximum lift force coefficients for any arbitrary geometry has obvious implications for the aircraft design groups at Langley as well as industry. Modeling non-linear aerodynamics also has direct impact on the accuracy of the FlightStream results obtained for aircraft in take-off and landing configurations. Further, the analysis of propeller-wing interactions can now be extended to include the effects of flow separation, and Research in



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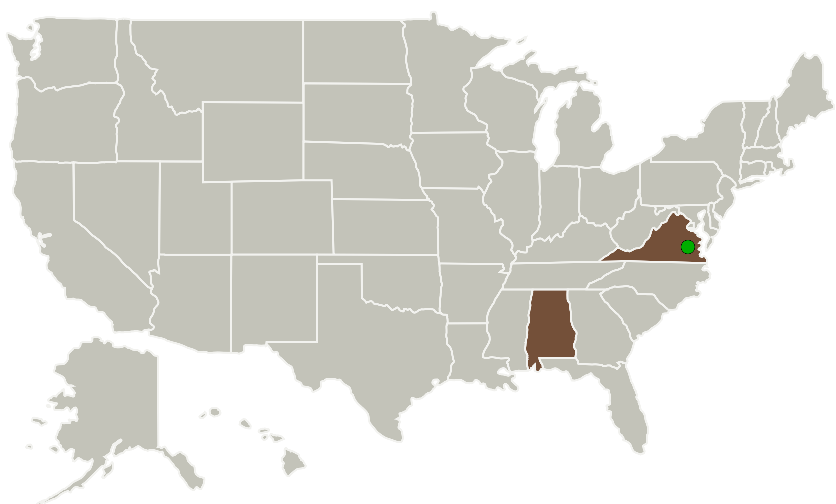
Flight hopes to validate these enhancements within the framework of the NASA X-57 design effort in the near future in conjunction with NASA design engineers.There is a significant overlap in FlightStream applications between NASA and the aerospace industry at large. Any enhancements made for a NASA effort is directly felt across the ever-growing FlightStream user community across the country. There are, however, additional FlightStream applications that are unique to the aerospace and marine industries. Primary FlightStream applications in addition to those in use at NASA include the modeling and performance of engine inlets, boundary-layer ingestion modeling, marine propellers and a potential future application for solid rocket motors (this is currently under development by Research in Flight). Most of these applications are positively affected by the development of the non-linear aerodynamics and flow separation models described in this document. For example, modeling boundary-layer ingestion is made possible because of the vortex shedding models described in this effort. Similarly, marine propeller analysis is now of higher accuracy as a result of the strain-based separation models developed as part of this NASA effort. These non-NASA applications are expected to increase the commercial appeal of FlightStream to the general aerospace and marine industries. Research in Flight expects to begin initial outreach efforts to industry to increase awareness of these newly forming FlightStream capabilities in early 2017.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Research in Flight

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Irian Ordaz
Keith L Woodman

Principal Investigator:

Winfred E Foster

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Organizations Performing Work	Role	Type	Location
Research in Flight	Lead Organization	Industry	Auburn, Alabama
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Alabama	Virginia

Project Transitions

May 2017: Project Start

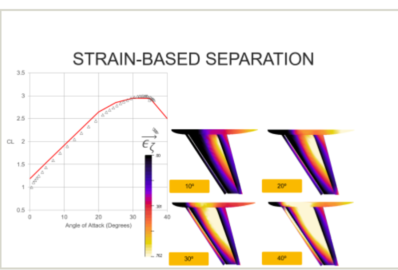
November 2020: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/141117)*

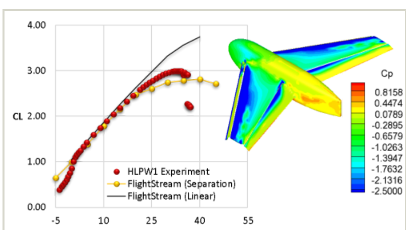
November 2020: Closed out

Closeout Documentation:
- Final Summary Chart PDF*(https://techport.nasa.gov/file/141116)*

Images



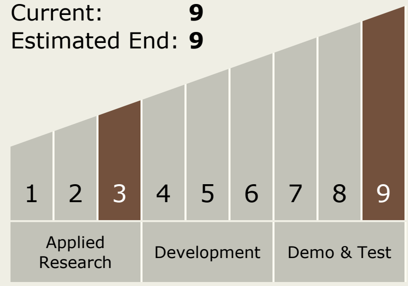
Briefing Chart Image
Robust Prediction of High Lift Using Surface Vorticity, Phase II Briefing Chart Image
(https://techport.nasa.gov/image/132223)



Final Summary Chart Image
Robust Prediction of High Lift Using Surface Vorticity, Phase II
(https://techport.nasa.gov/image/133015)

Technology Maturity (TRL)

Start: **3**
Current: **9**
Estimated End: **9**



Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System